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Invited Paper

ED100: Shifting Paradigms in Design Education and Student Thinking at KAIST

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Abstract
Freshman design courses offer a number of benefits to incoming students and are becoming increasingly popular in universities around the world. At KAIST, an innovative freshman design program has been developed that challenges some of the existing paradigms in design education in general and freshman design education in particular. This paper will discuss the basic format, goals, and philosophy for the freshman design program at KAIST. It will also address the successes, challenges, and future implications for the course.

Keywords:
First Year Education, Design Theory

1 INTRODUCTION

Freshman design courses offer a number of benefits to incoming students and are becoming increasingly popular in universities around the world. At KAIST, an innovative freshman design program has been developed that challenges some of the existing paradigms in design education in general and freshman design education in particular. The aim of the course is to improve the students' abilities to think independently, consciously, rationally, systematically, and synthetically. The course is intended to help the students become leaders by causing a paradigm shift in the way that the students think, view education, view the world, and view their role in the world. This is accomplished by having students apply formal design theories including Axiomatic Design Theory, traditional product design, and TRIZ to semester long design projects. This paper will discuss the basic format, goals, and philosophy for the freshman design program at KAIST. It will also address the successes, challenges, and future implications for the course.

2 PRIOR ART

Freshman design courses are offered in a variety of formats and for a variety of reasons. The last major survey of freshman design courses was done in 1997 by researchers at Stanford University. It revealed that the format of freshman design courses varies widely. Some courses focus on individual work, while others focus on teams. Course activities include case studies; deconstructing and reverse engineering artifacts; actively engaging in design projects; or a combination of these activities [1].

Freshman design courses sometimes appear as general or department electives. For example, 2.00B: Toy Product Design is a successful freshman elective currently offered by Barry Kudrowitz and Prof. David Wallace from the Mechanical Engineering Department at MIT.

Freshman design courses are often part of the required curriculum for students in individual departments or for all engineering majors. Both Northwestern University (DSGN106: Engineering Design and Communication) and Harvey Mudd College (E4: Introduction to Engineering Design) require a freshman design course for all first year students in the School of Engineering. These courses sometimes include modules to expose students to engineering technology (drawing and sketching, CAD, etc.) and common software programs (MATLAB, Excel, etc.) that they will need during their engineering careers. It is also increasingly popular to focus part of the course on team work, communication, and other "soft" skills which are important for professional careers in engineering.

Only two schools are known to require a design subject for all incoming students regardless of major. Colorado School of Mines offers EPIC151: Design I. KAIST offers ED100: Introduction to System Design and ED101: Communication for Design. Both schools specialize in mathematics, engineering, science and technology and do not offer general liberal arts degrees.

Many of today's biggest and most successful freshman design courses are what Sheppard and Jenison refer to as 'team process centered courses'. These courses are "principally centered around" and "dominated" by "one or several multi-week design projects."[1] These courses are sometimes the first in a larger undergraduate design sequence. They are treated as 'cornerstone courses' and are developed with the intent of ultimately preparing students for design capstone courses.

3 MOTIVATION

There are many good reasons to offer freshman design courses. They help to reduce the attrition of undergraduate engineering students, address requests from industry for a more prepared workforce, and satisfy ABET requirements for design in engineering education [2]. Freshman design classes are often fun and exciting. They help students gain hands-on engineering experience which provides context and motivation for

upper level engineering courses. They often have concrete results which can increase student satisfaction and build confidence. Finally, most project based freshman design courses rely on mentoring systems which allow students to have more personal contact with faculty, graduate students, upperclassmen, and engineering professionals.

Many of these benefits are shared by ED100 and ED101 at KAIST, however they were not the primary motivation for the creation of the course. Instead, the new freshman design course at KAIST is part of a larger initiative to revolutionize the university and its student population.

3.1 KAIST Revolution

During his inaugural address at KAIST, President Nam P. Suh stated that one of the major goals of the university was "to produce the next generation of leaders for society, industry, and academia."[3] His vision was for KAIST to become "the place where innovative, new ideas and concepts are created that change the way people think and approach challenging issues. It will be where … disruptive technologies are generated. Most of all, it will be the place where our planet's future leaders - in all fields of human endeavor - are groomed through the rich education and varied experiences they receive and the professional and personal relationships they form."[3] To achieve these goals, KAIST is working to create a campus-wide culture of "design thinking."

3.2 Design Thinking

Dym et al. say that good design thinking includes: divergent-convergent thinking; systems thinking; the ability to tolerate ambiguity and uncertainty; the ability to make decisions; the ability to work in teams; and the ability to communicate through various media and in the multiple languages of design [4].

Stephen Lu adds the following characteristics of good design thinking: "synthetic (rather than analytical) thinking; functional (rather than physical) thinking;…constructionist (rather than determinist) thinking; solution-neutral (rather than solution-specific) thinking; demand-driven (rather than supply-based) thinking; want-pull (rather than need-push) thinking; price-based (rather than cost-based) thinking; top-down (rather than bottom-up) thinking; [and] socio-technical (rather than pure-technical) thinking."[5]

3.3 Need for ED100

Surveys have shown that 85 – 90% of the students in the incoming freshman class at KAIST have never participated in a design project before. Their education before entering university has been rigidly structure with little freedom for choosing courses or exploring interests. Information has been "pushed" to the students, instead of giving them the opportunity to "pull" the information that they want or need. As a result, students are often more preoccupied with grades than learning.

High school coursework for KAIST students has typically focused more on memorization and calculation than on analysis and synthesis. The students are used to working with specific instructions, rather than independently evaluating the situation and choosing the best path for their work. Finally, the evaluation of their work has been done with more tests than projects. As a result, these students have little experience with open-ended poorly-defined questions and are initially uncomfortable with these types of assignments.

3.4 Goals for ED100

ED100 is intended to cause a major paradigm shift in the way that its students think, view education, view the world, and view their role in the world at KAIST. The course aims to help students to become conscious, rational, independent, systematic, and synthetic thinkers. Students are expected to learn to question, evaluate, and make decisions. They are expected to learn how to teach themselves and learn independently. They are expected to develop and refine teamwork and communication skills, and gain experience and confidence. Finally, it is hoped that students will begin to recognize the value their education and understand that their abilities can (and should) be used to make a positive difference in the world.

4 FRESHMAN DESIGN AT KAIST

The freshman design course at KAIST is formally composed of two courses: ED100: Introduction to System Design (3 units) and ED101: Communication for Design (1 unit). The two courses are taught as a single, unified course and are separated only for administrative purposes. The combined course will be referred to as 'ED100' in this work for simplicity. ED100 is required for all incoming students regardless of major. Approximately 400 students (half of the freshman class) take the course each semester. The course was first offered as a freshman elective in Fall, 2007. It has been required since Spring, 2008.

4.1 Course Overview

ED100 is a 'team process centered' course with a single 16 week long design project. Each semester, up to 20 different projects are offered and students choose their topic by lottery. Each project is assigned to four or five teams which are composed of four to six students each. Project advisers come from all departments at KAIST and are welcome to offer any project topic that satisfies the provided guidelines. Internal and external clients who bring their own design project topics to the course may be introduced in the Fall 2009 semester.

Although projects are typically related to engineering or product design, they are not required to be. During the Fall 2008 semester, a professor from the School of Humanities and Social Sciences offered a very successful project on policy design to bridge the digital divide. A project to design educational curriculum will be offered in the Spring, 2009.

All course lectures, laboratory sessions, materials, assignments, and activities are geared towards the deliverables of the final projects. Students attend 1 hour of design lecture and 1 hour of communication lecture per week. They also have 3 hours per week of design laboratory where they meet with their faculty project adviser and 1 hour per week of communication laboratory with a faculty communication adviser. Students attend all laboratory sessions as a team.

In many ways, ED100 is structured more like a traditional senior capstone course than a freshman cornerstone course.

4.2 Design Projects

In any design project, the designer needs three types of knowledge: (1) knowledge about design and the design process; (2) domain-specific or subject-specific knowledge; and (3) knowledge about the particular problem at hand. Most incoming students in a design class will have no previous formal experience or knowledge of design and will have to learn that material during the course. This is true for both capstone and cornerstone students. In addition, all designers, no matter how experienced, have to study their particular problem as part of the design process. This is equally true for freshmen and seniors. The major difference between capstone and cornerstone courses is that the first year students will not have the same domain-specific or subject-specific knowledge that juniors and seniors in a

similar course will have. To address this, ED100 requires that all projects offered be unsolved and important real world problems which do not require strong domain-specific knowledge. Because the course focus is on conceptual design, problems must be defined in a solution neutral manner and have a large solution space. Any domain-specific information or resources that the students need is provided by their project advisers and teaching assistants or learned through background research.

4.3 Design Lecture

In ED100, there are 10 lectures during the 16 week semester. There are no classes or laboratory sessions during the mid-term or design review weeks. The remaining weeks in the semester are unscheduled to give students more time to work on their projects.

"Design lectures are primarily based on material from Axiomatic Design (AD) Theory [7] and traditional product design [8]. Classical AD assumes that the student is already familiar with design and that they will use AD to supplement and modify their design thinking, rather than building it from scratch. The material from product design is used to create a more holistic course for novice designers. The lectures are also supplemented with materials from Altshuller [9], Pahl and Beitz [10], Simon [11], Suh [12], and others.

The lectures introduce various definitions of design, design methods vs. design methodologies, and design thinking. Problem identification, problem clarification, and background research are discussed. Different design processes are introduced and compared. Customer needs and customer research are addressed. Functional thinking, functional requirements, and the independence axiom are introduced. Strategies, concepts, and design parameters are explored and compared.

Concept refinement techniques from AD, TRIZ, and other areas are introduced. Students are encouraged to locate and fulfil hidden needs; eliminate coupling, conflict and bias; consider physical integration; introduce flexibility and modularity in their designs; use hidden or free resources; recognize and increase the level of innovation in their concepts; and to increase the overall ideality of their designs.

Students learn about concept testing, concept selection, customer testing, and prototyping. A guest lecture on intellectual property in the US and in Korea is offered. The process domain and design implementation are discussed. Finally, the design matrix is discussed in more detail and advanced techniques for identifying coupling in the matrix are presented. Bonus lecture materials are available on complexity and the information axiom but are not presented in class."[6]

4.4 Uniqueness of Lecture Materials

The emphasis on design theory and design thinking in ED100 is very unusual in both cornerstone and capstone classes. Sheppard noted that "[w]hile all of the [multi-week project based] courses reviewed do talk about design methodologies to some extent, in some cases this discussion is much more extensive. For example, at Harvey Mudd College, students engage in a number of exercises that have them explicitly consider a variety of design methods/ strategies. In addition, Harvey Mudd's course relies heavily on exposing students to design case studies."[1]

The Harvey Mudd course addresses various aspects of the design process including: problem definition; objectives and functions identification; morph charts; performance specifications and metrics; generating and evaluating alternatives; proof of concept and prototyping [13]. But it does not seem to cover the material in the same breadth or depth that ED100 requires.

In this respect, ED100 stands alone. Axiomatic design theory is offered primarily in graduate engineering subjects [14-17], as university professional short courses [18-19] and through short courses offered by industry [20]. AD has been used in capstone design courses in the Mechanical and Electrical Engineering Departments at the University of Idaho [21]. It has been combined with a variety of other design tools and theories in an undergraduate capstone course at Ryerson University in Canada [22]. It is also compared to other design processes in an undergraduate materials design course at Northwestern University. However, AD and other formal design theories are still relatively uncommon at the undergraduate level and unheard of in the growing field of freshman design education.

4.5 Grading Philosophy

The unique motivation and philosophy of ED100 are also apparent in the way that the course deliverables are defined and evaluated.

4.4.1 To Build or Not To Build

Many undergraduate design courses strongly emphasize design realization (building). However, there is a risk that students will focus on "doing" at the expensive of "thinking" when faced with the pressure of impending deadlines (Students sometimes refer to this as "hacking things together.")

Design implementation in ED100 is encouraged but not required. Some projects will have full working prototypes, but the majority will rely on sketches, sketch models, movies, dioramas, or other media to communicate their ideas. It is expected that students will have additional opportunities to do detailed design and build-and-test in upper-level design courses offered within their departments.

4.4.2 Breaking the Rules

"Novices in all fields, including design and communication, tend to seek "the rules", while experts tend to ask "what are we trying to do?" In ED100, there are no "rules" which students must obey. Instead, students are exposed to different ideas, opinions, tools, and guidelines. The students, then, choose which aspects of the lecture materials to apply to their design projects and how to apply it based on their needs. The emphasis is on whether or not the students' decisions make sense, and whether or not they can explain and defend those choices."[6]

4.4.3 Grading Guidelines

A full 50% of the final grade in ED100 is based on the final deliverables (10% poster, 20% paper, 20% technical evaluation.) The rest of the grade is based on design and communication laboratory attendance, participation, and assignments, and peer review. Roughly half of the grade is based on individual work and half is determined by the group's performance.

The paper and poster grades are based on how well students have communicated their ideas both verbally and visually. The technical evaluation is based on how well students have understood and applied formal design theories and other lecture materials to their project. Students are specifically judged on their problem statement (7.5%); design process (12.5%); design concept, feasibility, and results (50%); risks and countermeasures for their design (10%); and their use of axiomatic design theory (20%).

The contribution of axiomatic design theory to the final grade is relatively small to allow students the freedom to

use other design theories if desired. Trial-and-error and intuitive design are not permitted and result in a severe grading penalty. All design decisions must be explained and justified. Success is evaluated not just based on the quality of the resulting design from the viewpoint of the faculty members doing the grading, but based on the students' ability to understand, explain, and substantiate their work.

Instructions and grading criteria are available to the students for all assignments through the semester, including the final deliverables so there is no confusion about course expectations.

5 RESULTS

The success of ED100 has been evaluated through a variety of metrics including the quality of the final projects; continuing work; and unsolicited feedback from students and faculty.

5.1 Final Projects

Overall, the final projects in ED100 have been very good and are improving every semester. Teams have strong statistics, customer data and/or expert interviews to demonstrate the need for their design and substantiate their customer needs and functional requirements. Designs tend to be uncoupled or decoupled in accordance with principles from axiomatic design and TRIZ. The level of innovation for most of the projects is high. Few projects are merely new combinations of existing ideas and no projects rely on incremental improvements. The viability of the projects is supported by calculations, experiments, or customer testing data. In addition, some teams have full working prototypes.

The number of working prototypes in ED100 is on the rise despite the fact that prototypes are not required. Teams produced working ducted-fan type unmanned aerial vehicles (UAVs, figure 1) and air-drop vaccine containers which successfully survived being thrown off of tall buildings. Modular eco-friendly paper furniture including portable benches (figure 2), a desk which retracts into the ceiling and bookshelves which can be reconfigured into chairs were produced. Students also designed and built bio-mimetic robots that could climb stairs (figure 3) and navigate rough terrain. Some of the designs and prototypes that are being produced are junior/senior level work and not what one would normally expect from a freshman design class.

Finally, all projects use formal design theories and processes to produce their final design. Not only do the students use design theories, tools, and techniques that are presented in class and are discussed in the course texts, students have begun to use tools, techniques, and theories from other areas of design and from fields outside of design. One team from the Fall, 2008 semester used the '3c STP 4p' framework from marketing to integrate non-functional requirements and qualities into their design [24]. Other teams used evaluation graphs, gap maps, pair wise comparison matrices, and synthetization in their concept selection processes although none of these techniques were presented in class or in the textbook [25-27]. These examples show that students are demonstrating genuinely synthetic thinking and are starting to "pull" information from other classes and other sources to meet the needs of their design projects.

5.2 Continuing Work

At the beginning of ED100, students rarely know about patents, publications, and other indications of success outside of grades. Fewer still understand the value of these indicators. Students will often request extra credit for filing patents in the hopes that this will improve their grades. The response is always to inform the students that a patent, paper, or other type of publication is more valuable than the grade and to remind them that the focus of the course is on their future instead of on their GPA. It seems that some of that message is getting through.

After the Fall 2007 pilot of ED100, three teams were invited to present their design projects at the Fifth China-Japan-Korea Joint Symposium on Optimization of Structural and Mechanical Systems in Jeju, S. Korea. A fourth team continued their work as an Undergraduate Research Project (URP). These students presented their work as a research paper at the 21st International KKCNN Symposium on Civil Engineering in Singapore [28] and won an award for best student presentation.

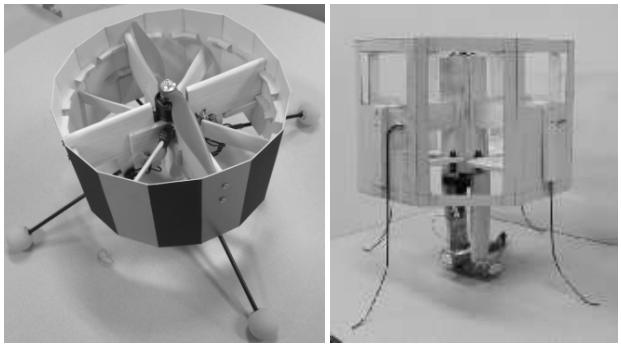

Figure 1. Agricultural (left) and Surveillance (right) UAVs

Figure 2. Portable Eco-Friendly Paper Bench

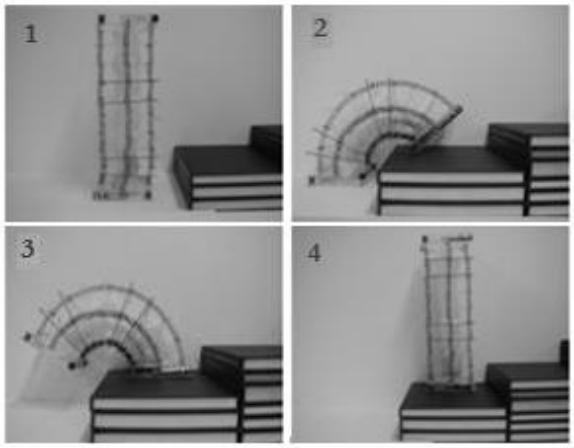

Figure 3. Stair-climbing "Slinky" Robot (Video Screen Captures) [23]

After the Spring 2008 semester, one team continued their work as a URP and filed six patents on their design for a remote control (RC) helicopter charging platform. In addition, Samsung Electronics invited nine teams with projects related to the company's interests to participate in a 'KAIST Freshman Invitation Competitive Seminar'.

After the Fall, 2008 semester, two teams filed patents based on their designs for innovative toy water guns. Students from three additional teams traveled to Lisbon, Portugal to present their work as research papers at the

5th International Conference on Axiomatic Design [23-24, 29].

5.3 Unsolicited Feedback from Faculty

"Unsolicited feedback from various faculty members associated with ED100 has generally been very positive. Many faculty members regularly voice their support for the course and express interest in continuing to be a part of the course as time allows. However, there were some initial reservations about the course, including concerns that the students did not have enough domain knowledge to do design, or that the course material was too non-traditional or not applicable to all students and majors. As time goes on, those concerns seem to be diminishing. One of the project advisers from the Spring 2008 semester sent the course coordinators (and the president of the university) an email with the following statement:

> "At the beginning of this semester, I was uncertain about whether this kind of design course would work for freshmen. … However the seriousness and heated atmosphere of the students in the team discussion convinced me that they know what they are doing and this course will work. I was also re-convinced that you don't need to be a master or PhD to be a good designer."

The greatest strength of any educational experiment is not shown by its initial supporters, but in those who are convinced after experience with the project."[6] Comments of this kind not only indicate the success of the course. They also demonstrate a shift in faculty perceptions about the course and about design education.

5.4 Unsolicited Feedback from Students

"Similarly, the initial response of the students to ED100 is frequently mixed. The course material is new to all of the students and very challenging. Students often complain that the course work load is too high and the course itself is too fast-paced. They also sometimes feel that the lecture material is "trivial" or "useless" at first and that the course should not be required. However, these opinions often change after the students have completed their project and participated in the poster fair. One student email to the course coordinators from the Spring 2008 semester said:

> "I want to give my thanks to you. Frankly speaking, even until the last period of the semester, I didn't like this class because the homeworks [sic] was too hard, big and a lot.
>
> But, during doing the poster fair and presentation, I changed my mind. I thought that it is just hard and doesn't help my study, but now I think that it changed my view of thinking. And I also could feel the happiness of accomplishing something with the members with same object. It was really the one of the happiest things in my first semester.
>
> I like your class and thank you for giving me the chance to have this good experience^^."

(Note: The double carrots at the end of the statement are the local equivalent of a smiley face.) Similar sentiments were echoed by a student from the Fall 2008 semester:

> "To be honest, this course was one of the toughest courses that I have learned since my elementary school years :) Also, as our team's project topic was not making any tangible thing, but rather creating a policy, it was a lot tougher. Getting started was such a huge job that it took us more than about three weeks to get the idea of what we are going to do. However, after the poster fair and all those difficult days are past, I think we learned a lot! I feel really thank you for this course for giving me such precious lessons! Hope the coming freshmen students next year learn a lot from this course as well :)"

These statements are significant for three reasons. First, again they show that the course is successful in accomplishing its goals in changing the students' attitudes towards their education and their role in the world. Second, they show that students who were not initially supportive of the course were convinced of its value through their experiences. But they are most important because surveys have shown that most undergraduate students do not realize the full value of their experiences in design courses until 5 years after graduation. The fact that these students are beginning to recognize the value of ED100 both for themselves and for future ED100 students after only a single semester is phenomenal."[6]

5.5 Paradigm Shift in Student Culture

There are strong indications of the beginning of a paradigm shift in student attitudes as a result of ED100. ED100 faculty have observed that students are increasingly comfortable with expressing themselves in English. They are becoming more vocal and pro-active both inside and outside of the class. Their questions and comments frequently demonstrate a very mature and impressive understanding of design. They actively seek help and look for feedback. They are beginning to debate with each other and their professors. And, we are finally starting to see students valuing the results of their work (and the opportunities and rewards) that exist outside of grades. Although these changes may seem small, they are a drastic departure from the traditional Korean educational system. However, the observations from the students themselves are even more important.

One group of students observed that because of ED100 "[t]he homework mentality was broken, and rather than considering the tasks as a simple assignment, the students generally tried their best to create something to the best of their ability. The students generally react to courses considering cost to credit/grade ratio, despite the course ED100 being another three credit course, students spent immense amounts of time and thought independently in order to improve upon their design, exploring possible applications of their design, and also exploring other possible applications of the design process. Even jokingly the students would bring up concepts from the lecture during casual conversation, indicating that the concepts and theory taught in during the course were deeply penetrating." [24]

The same students also observed that the course changed the landscape of competition between students. "The competition, although subtle, was also a large factor in motivating the students to strive for excellence. Considering the grade/credit to time invested ratio, grades were not the cause for competition, especially because the projects were not graded on a curve. We were able to identify three major sources that created competition. The first was the potential recognition and award, highlighted by an award ceremony at the end of the semester. The second source was competition amongst the students across different projects, all striving to generate the best possible designs for each project. However, the strongest competition was between the teams that dealt with the same projects. This friendly, but fierce, competition motivated the students to come up with better and more creative solutions than the other teams, creating different types of satisfaction in the involvement of the course."[24] This again indicates that students are beginning to value their education over their grades and are beginning to understand that solving problems is sometimes more important than the potential rewards involved.

Changes in attitudes towards teamwork were also observed. “[T]he unique characteristic about ED100 is that it does not allow the students to split the work load and work independently. It requires the students to work together. Our advising professor Jung Kim repeatedly informed us that collaboration and harmony would be required for the success of the project rather than equal distribution and specialization of the tasks.”[24]

Perhaps most surprising are not the changes in the attitudes and behavior of the students, but the fact that the students themselves recognize the changes and are able to articulate them so well.

5.6 The Long Road Ahead

Despite the apparent successes, there is still a long way to go. There is still a lot of confusion and debate about the definition of “design” for both the students and the faculty and the value of AD. The term “design” when translated directly into Korean strongly implies aesthetic or industrial design. It also frequently equated with “creativity” and “optimization” in Korea. It is uncommon to see design discussed as a larger field and within a larger context. This is demonstrated in some of the comments from students in their final surveys.

One student recognized the differences between the more common definitions of design that they are used to and the course material. However, they do not appreciate the role of axiomatic design in the design process. AD is seen as an impediment to creativity and ideation, instead of a way to help organize and focus those efforts.

> “What I've found out is that the way most of the teams thought of 'designing' was very different from the 'designing' that this course tended to do. We thought all we needed to do was think of a good idea and finalize it into an awesome product. But this ED100 designing was trying to create 'something' from 'nothing' which didn't allow any creative, popping ideas to be fulfilled directly. If I were to teach this class, I'd give the topic and develop it without the FRs and DPs and get onto specifying people's ideas right away. In this way, the teams will be relieved from the stress of FRs and have fun making their product more attractive and useful.”

Another student’s comments indicate that the course has not adequately explained why is will never be possible to optimize a poor design into a successful one. Although, it does seem to have succeeded in helping them learn to value patents:

> “It was helpful in that we had to find solutions for problems in a different method, but we did not have a chance to optimize existing systems, which would actually be the realistic, "patent inducing" design approach that could actually assist in creating realistic solutions.”

These alternate or limited views of design are sometimes reinforced by television, faculty, family, and friends. Shifts in student thinking sometimes happen very rapidly, but changes in attitudes of those around them can take much more time.

Despite the obvious disappointments, these detailed comments show that the students are beginning to value “design” – whatever it is. They are also beginning to evaluate the design process that they used and suggest alternatives or improvements. These represent the third (valuing), fourth (organization), and fifth (characterization by value set/internalization of the value) levels of Krathwohl’s taxonomy in the affective domain [30]. This, in itself, is a major achievement.

Other student comments from the final surveys do express an understanding of and an appreciation for axiomatic design theory and the course materials. The extent to which the majority of students do (or do not) appreciate some of the more formal aspects of the course is not known at this time.

6 DISCUSSION

There are many challenges associated with running any large design course and ED100 is no exception. However, some of the challenges in ED100 are specific to the course.

Most of the design theories being covered in ED100 were originally developed by or for mechanical engineering or product design. Although many of them were intended to be universally applicable to all areas, the course material is still more suitable for some projects than for others. This is a challenge both for the faculty and the students and is reflected strongly in the survey responses.

In addition, because the course material is being combined from different sources and because some of the material has never been taught to first year students, the course material is constantly evolving and no unified textbook is currently available for the students. A textbook is planned for the course and should be available within a few years but this is little consolation for the current students. The course currently uses either Ulrich and Eppinger [8] or the Northwestern EDC text by Yarnoff, et al [31].

Despite the challenges, there are also many opportunities especially for the advancement of design education and design theory. ED100 provides an unprecedented occasion to study how undergraduate students learn axiomatic design theory and other formal design theories and apply them to non-traditional areas including chemical and biological engineering; human-computer interaction; policy design; educational design; and more. It is also an excellent opportunity to better understand how these various theories and design fields work together and to identify the agreements and disagreements between them.

7 CONCLUSIONS

A new required freshman design course at KAIST has been developed which challenges traditional ideas about freshman design education and which is successfully producing a paradigm shift in student thinking, attitudes, and culture. Despite the challenges, the future of the course, both as an educational vehicle and a research opportunity for design theory and education, looks very bright.

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